ESTIMATING A EUROPEAN DEMAND FOR MONEY

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Abstract

European Monetary Union will come into existence in 1999. This raises questions related to the monetary policy targets that will be adopted by the European Central Bank (ECB). For both likely candidates, targeting a money aggregate or an inflation target, the existence of a stable money demand function at a European level is important. In this paper estimates of such a European money demand for narrow and broad money for the actual 11 EMU countries based on quarterly aggregate data from 1964 to 1994 are presented. It is argued that statistically satisfactory and economically interpretable functions can be found. The robustness of the results is further evaluated using alternative country groups. Moreover, the estimated models appear to be stable over a period of 20 quarters. This raises the hopes that the ECB will face a stable money demand and be able - at least for a certain time - to use past aggregate data for policy purposes.

Keywords: European Money Demand, Monetary Policy, European Monetary Union

JEL: E41, F33, E52, E47

1. Introduction

As a result of the decisions made by the EU heads of government in the European Council on 2 May 1998 concerning the participants of European Monetary Union (EMU), EMU is going to start in January 1999 as originally set out in the Treaty of Maastricht.

One of the more controversial issues left on the agenda is the formulation of European Central Bank (ECB) policies, and especially the question of targeting a monetary aggregate versus using an inflation target. While the former is strongly supported by the German Bundesbank, the latter has been adopted by the UK government since 1993. But as the UK is not going to be a founding member of EMU, money targeting is likely to become the dominant strategy. Otmar Issing, chief economist of the ECB, has indicated, though, that he could imagine using an inflation target as an additional monetary policy target (Issing (1998)).

Controlling a money aggregate presupposes the existence of a stable demand for money. If money demand fluctuates wildly, the transmission mechanism of monetary policy becomes extremely complicated, and the ability of the central bank to control money, and thereby inflation, is severely reduced.

However, even the use of an inflation target does not really alleviate the problems connected with an unstable money demand, the reason being that it is simply not possible to control inflation directly. Hence the term 'inflation targeting' hides the fact that the link between inflation and monetary policy is not a straightforward one and, moreover, the time-horizon of inflation targets tends to be medium-term. Thus, money aggregates are likely to continue performing an important role as a source of information for forecasting inflation rates and an intervention indicator for monetary policy.

Consequently, the work of the ECB would be greatly simplified if the demand for the single European currency, the Euro, was a stable function of a small number of variables. In this paper we are concerned with the attempt to empirically estimate such a European money demand function. We are trying to find out whether something like an aggregate demand relationship for the Euro could exist, how it may look like and whether it is likely to be stable or not.

There exist a number of articles in the literature on this issue. Here we just want to sketch some of the more important contributions. For a general overview see van Riet (1993), Monticelli and Papi (1996) and Bruggeman (1997b). The seminal paper is the one by Kremers and Lane (1990). They postulate that an interpretable and stable European (they chose an aggregate of seven countries) demand for narrow money can be found. Some criticisms on their study are raised by Arnold (1992) and Barr (1992).

A study involving European money demand estimates for M1 and M2 is presented by Artis et al. (1993). Using a similar approach, but allowing for a different way of converting the variables denominated in the respective national currencies, they also find a stable money demand equation. Monticelli and Strauss-Kahn (1993) perform an analysis based on M3, including all ERM members in mid-1992. See also Bruggeman (1997a) on the influences of using different broad money aggregates and Wesche (1997) for employing Divisa money.

A closer investigation of the validity of the aggregation process for the four major EU countries has been undertaken by Wesche (1994). Her general conclusion is that the aggregate money demand function is useful for forecasting purposes and the aggregation bias is considered relatively modest for Germany, France and Italy. Artis et al. (1993) raise a related point on the problem of aggregation.

The question of the adequacy of aggregate money demand equations is addressed from a microeconomic utility-maximising perspective by Janssen and Bhundia (1998) and Spencer (1997). The latter finds that the use of aggregate EU data is supported by the utility-maximising framework. Contrary to this result, Janssen and Bhundia (1998) argue that since monetary aggregates are not weakly separable from real income, the simple construction of an EU-wide aggregate is invalid. While their approach is interesting as an application of a stringent methodology, it is unlikely that many national money demand functions would pass their empirical test and it is unclear whether their statistical rejection of weak separability is economically relevant.

A useful summary of issues surrounding the estimation procedure and a survey of existing national money demand estimates for the EU are provided by Fase (1994), Monticelli and Strauss-Kahn (1992) and Browne, Fagan and Henry (1997). Fair (1987) gives an older but extensive comparison of money demand estimates involving 27 countries, including EU members. Cassard, Lane and Masson (1997) show, additionally to providing money demand estimates for some EU countries, that a European monetary aggregate improves the prediction of German inflation compared to using a German aggregate.

Some critical remarks concerning the whole procedure of estimating aggregate European money demand functions are expressed by Arnold (1994). He does not believe in the argument that these aggregate functions are more stable than national ones because they incorporate the effects of currency substitution. In his cross-sectional analysis he cannot find evidence that smaller countries show greater instability of money demand functions than larger countries. However, a different position is maintained in Lane and Poloz (1992), Angeloni et al. (1994) and Spencer (1997), who argue that currency substitution is important.

This study seeks to extend the literature in several directions. First, a somewhat more developed econometric methodology is applied for estimating the European money demand. Some evidence is presented that some of the money demand estimates reported in the literature should have taken place within a system context. Second, the actual group of countries which will form EMU in 1999 is used in the analysis. Third, a much greater emphasis is placed on evaluating the forecasting properties of the estimated European money demand functions than in the other studies.

In the following section, some important methodological problems are addressed. Section three explains the econometric approach, and the data base is briefly described. Then in section four we come to the estimation of long-run money demand equations for a group consisting of ten countries likely to form EMU. Finally, in the conclusion, the preceding results are brought together and are evaluated with respect to the overall statistical performance and policy relevance.

2. Some Methodological Problems

It needs to be stressed that there exist a number of problems with drawing conclusions from European money demand estimates for monetary policy. The most prominent problem on a theoretical level is the one connected with the idea of the 'Lucas' critique': To be able to put any economic meaning into the estimates of aggregate money demand functions for countries forming EMU, we have to assume that the future behaviour can be derived from past data. In other words, we assume that the creation of EMU and the use of the money demand estimates by the ECB will not lead to a structural break in people's behaviour.

A priori, this does not appear to be very likely, and Arnold and De Vries (1998) argue that there are indeed strong reasons to expect structural changes to occur. However, at least three arguments can be set forth to support the relevance of conclusions based on past behaviour. The first one builds upon the distinction between temporary and permanent effects of the economic shock. As an example, take the experiences from German monetary union. A considerable amount of research has been undertaken to examine the effects of German monetary union on national money demand. The results are not clear-cut, but a majority of studies point towards either finding no great effect or only a temporary one (see OECD (1993), von Hagen (1993), Falk and Funke (1995), Hansen and Kim (1995) or Wolters and Lütkepohl (1997)).[1] Thus even though the creation of EMU will cause a shock on the money market, this effect may well be only of a temporary nature. In this case, the ECB would have no great problems in accounting for the break and employing data from the pre-unification period as a guideline to monetary policy making. But there can be no doubt that EMU is a much greater undertaking than German monetary union, where the whole West-German political and economical system – including the way monetary policy is performed - was basically imposed onto East-Germany. Hence this comparison should only be seen as suggestive, but not compelling.

A second argument can be based on the potentially stabilising effects brought about by creating a monetary union of countries already forming a zone of free capital mobility - like the EU - whose respective citizens engage in mutual, i.e. intra-EU, currency substitution. Since economic agents can switch in and out of a national money very easily, their individually optimal economic action may cause the respective national money demand to become highly unstable. Now, if the countries which experience the biggest share of mutual currency substitution entered into a monetary union, these destabilising currency substitution effects would be removed by definition.

Empirical studies trying to measure the substitution effects are neither fully convincing on a methodological level, nor are the conclusions entirely clear (see e.g. Lane and Poloz (1992), Angeloni et al. (1994) or Arnold (1994)). In the analysis of national money demand functions presented by Hayo (1998, p. 164ff), for instance, little evidence of empirically important currency substitution was found. However, it is likely that even if currency substitution is not very important at present, it will become more important in the future due to an increasing degree of money market integration and the computerisation of trading patterns. Thus the reasoning would be that by forming a (large) monetary union, important prospective opportunities for currency substitution will be removed today and thereby future fluctuations in national money demand due to these currency substitution effects can be avoided.[2]

Third, there will be behavioural inertia in adapting to the new monetary framework. This is considered here as the most persuasive reason for the usefulness of European money demand

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[1] However, Funke (1996) claims to have found permanent effects.

[2] But there can still be currency substitution between the Euro and all other currencies left in the world economy, with much the same negative effect on the stability of European money demand.

estimates based on historical data. At the beginning of EMU, market participants will have to adjust to a situation which they cannot evaluate very precisely. They will need time to gain experience and learn about the new monetary environment. While this takes place they will likely continue to behave in the same way as they did before EMU, updating their behaviour when new information appears. After some time, say a couple of years, it will become clear how monetary policy will be conducted by the ECB and the adjustment process of economic agents will be complete. Therefore, the information gained by using past data is likely to yield only temporary insights and is bound to become obsolete with time.

If one of these lines of reasoning is accepted, past data can be used by the ECB as a basis for monetary policy. In any case, an attempt has to be made to make the best possible guess for the future.

Whether a future European money demand will be more stable is difficult to assess. As a stabilising force there is the increase of the currency area which will reduce the likelihood of idiosyncratic shocks and lessen the impact of destabilising currency substitution. This effect could be offset by a convergence in the behaviour of economic agents when they face an identical monetary policy environment in EMU. Moreover, there may be an increasing amount of currency substitution between the Euro and other monies in the rest of the world. Finally, money demand instability may also be due to the effects originating from financial innovations. The basic argument is that the creation of a monetary union will lead to increased competition between financial intermediaries, forcing them to offer more differentiated financial products and, consequently, that money demand instability will rise as a result of EMU.[3]

3. Aggregation, Econometric Specification and Data Base

Next we can address some of the numerous technical difficulties involved in the estimation of a European money demand function.

First, how do we aggregate the national economic values into ‘European’ variables? This could be seen as an important technical problem, and is regarded as such in many articles in the literature briefly reviewed above. However, much more difficult than the actual technical problems involved in computing these European values are the questions of interpretation.

[3] It is also possible, see for example Thornton (1994), that financial innovations eliminate monetary transmission mechanisms - like the credit channel - which are difficult to control by the central bank.

Even assuming that we are indeed measuring something like European variables, there remain many uncertainties. Apart from the general econometric problem that the empirically employed variables do not fully reflect their theoretical counterparts, we have to face the danger of getting aggregation biases (cf. Lovell (1973), Pesaran et al. (1989)). However, as pointed out theoretically by Grunfeld and Griliches (1960), there may also exist aggregation gains if we encounter specification problems at the micro level. Applying this reasoning, we would expect to find specification biases in the individual money demand estimates (a recent survey of the literature is given in Laidler (1993)), which may offset each other in the aggregation process This can be seen as another argument in favour of aggregating money demand functions.

The net effect of gains and losses from aggregation is difficult to assess in theory. Judging from the comparison of empirical studies of money demand in European countries (see Monticelli and Strauss-Kahn (1992) or Fase (1994)), we cannot a priori expect the aggregation bias to be negligible. This is a conclusion reached also by Wesche (1994), who uses a more formal empirical analysis to investigate the basis for aggregation of the four largest EU countries. A study by Hayo (1998, p. 164ff) demonstrates, however, that for almost all EU countries stable long-run money demand functions based on very similar specifications can be estimated. In particular, an income elasticity of unity was found for about half of the countries, while the variation in the estimates of the interest-rate semi-elasticity appeared to be somewhat higher. Hence it is unlikely that aggregation biases are excessively large.

The agreement reached by the European Council says that 11 countries will join EMU from the beginning. Since there are no separate data on money aggregates for Luxembourg available due to its monetary union with Belgium, we in fact only use 10 countries. But since this will not affect our results, the constructed aggregate is called EMU11 and it includes the following states:

EMU11 = Germany, France, Netherlands, Belgium, Ireland, Austria, Finland, Italy, Spain, Portugal.

Regarding the issue of econometric methodology, the approach applied here is similar to the one put forward by Clements and Mizon (1991) or Hendry and Mizon (1993). We start from a general VAR system and proceed by a sequential testing down process to simplify the model. This procedure has been termed ‘general-to-specific’ modelling (see Hendry (1993)).[4]

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[4] A recent survey of econometric methodology is presented by Hayo (1997).

After analysing the univariate time-series properties, with the finding of difference stationarity, the modelling of European money demand starts from an unrestricted VAR with five lags. This is sufficient to remove the autocorrelation of the residuals according to LM-tests. Then, in a sequential testing-down process, the lags are removed based on an F-test at a 5% (nominal) significance level. To capture the long-run characteristics of money demand functions, we estimate a stationary cointegrating vector, which can be interpreted as the long-run equilibrium of the model.

The testing and estimation of the cointegration vectors is done using the reduced rank procedure introduced by Johansen (1988). The main criteria guiding the specification are a theoretically consistent sign on the estimated parameters, and a negative α-value, which is the adjustment coefficient of the long-run equilibrium in an error-correction model. A plausible adjustment parameter should be negative and large enough in absolute terms. The former is necessary to interpret the relationship as an error-correction mechanism, while the latter ensures that the cointegrating relationship influences the short-run dynamics in an economically, and not only statistically, significant way (see McCloskey and Ziliak (1996)).

Moreover, the estimates of the adjustment vector can be used to test for weak exogeneity of the included variables, which has been demonstrated by Johansen (1992a, 1992b). As discussed in Engle et al. (1983), when the variables are weakly exogenous with respect to the parameters of interest, we do not have to model the marginal process. In other words, if it should turn out that the adjustment parameters were not significantly different from zero for the equations explaining GDP growth and interest rate changes, no significant information would be lost when modelling the money demand equation using just a single equation instead of a three-variable system.

A crucial point to note is the dependence of the whole analysis on the stability of the estimated money demand relationship. Only if the resulting equation is stable can we claim to have estimated a money demand function at all, as the dependent variable is a monetary aggregate, which is a reduced form of the effects of money demand and supply. To be able to identify the equation as a money demand function, it needs to be stable, and all the movement must be attributable to changes in money supply.[5] To stress the importance of this aspect, as well as the significance of stability from the point of view of monetary policy, we have reserved 20 observations for forecasting purposes.

[5] Alternatively, identification would be possible by assuming a perfectly elastic money suppley. However, this does not appear to be very realistic.

The variables employed in this study are both narrow (usually M1) and broad (usually M3) money, income as a scale variable (GDP), and long-run interest rates (typically government bonds rates) as a measure of the opportunity costs of holding money. We use long-term interest rates for the analysis, as recommended, for instance, by Poole (1988).[6] The long-run interest rate can be viewed as an average of future expected short-term rates assuming that the expectations hypothesis of the term structure holds. While the money and income variables enter in logarithms, the interest rate is in levels, i.e. in percent per year. This is standard practice, rationalised, for example, in Fair (1987).

Adding other variables, like US interest rates or exchange rates, does not appear to improve the estimates very much. Rather, the forecasting performance of the system tends to decrease. And since it is believed that simplicity is important in econometric modelling (see Hayo (forthcoming) for some methodological arguments) it was decided to work within the framework of this small VAR system. Thus, we specify the long-run equation in the following form:

$$LM_t \, (\text{or } LMQ_t) = \beta_1 LGDP_t + \beta_2 INT_t + v_t \qquad (1)$$

where:

where:	LM	=	log of real narrow money
	LMQ	=	log of real broad money
	LGDP	=	log of GDP
	INT	=	aggregate interest rate
	β_1	=	income elasticity of money demand
	β_2	=	interest rate semi-elasticity of money demand
	v_t	=	white-noise error.

These are aggregate values, and it is necessary to at least sketch the derivation of these variables. Most of the national variables have been taken from the OECD data base on CD-Rom (Main Economic Indicators 1996/1), but some are also added from the International Financial Statistics series. Quarterly data are utilised, ranging from 1964:1 to 1994:4. Many of the series are seasonally adjusted, but some are not. Hence deterministic dummies are included in all of the regressions. Some national series had to be estimated from annual data or related series, using univariate representations, multivariate models or the procedure described in Chow and Lin (1973).[7]

[6] Due to problems of data availability, a short-term interest rate was employed for Greece, Spain and Finland. Considering their relatively low income weight, this should not bias the results very much.

[7] A complete source list of the variables, as well as the used data sets, are available from the author upon request.

In constructing aggregate variables, the following procedure, adapted from Kremers and Lane (1990), has been followed. First, purchasing power parities (OECD) from 1990 were employed to convert national currencies into Deutschmarks. Then aggregate nominal and real European income values are constructed by adding up the converted national values. From these two aggregates, a European income deflator is derived. This deflator is used to get real European money from the sum of converted national money aggregates. Finally, a European interest rate is created through weighing the national rates by the ratio of respective national real income to European real income, and adding them up.

Since the problems of avoiding strong movements of the actual exchange rates and the ones connected with using an arbitrarily fixed exchange rate are difficult to avoid, the use of purchasing power parities, in spite of its own weaknesses, appears to be the best choice. Artis et al. (1993), who use fixed exchange rates, report that their findings are similar to Kremers and Lane’s (1990) results based on applying purchasing power parities. Monticelli and Strauss-Kahn (1993) also report that their results are relatively insensitive to the way the conversion into a common currency is done. This indicates some robustness of the estimates with respect to the conversion procedure.[8]

Finally, we have to look at the time series properties of the created variables. In this paper, we have applied augmented Dickey-Fuller tests to investigate this question (see Table A1 in the Appendix). The results clearly show that the variables are difference stationary, in short I(1). These findings appear to be quite robust in respect of the way the augmentation is done. Therefore suffice to say that we excluded the lags using a sequential testing-down procedure, and checked the success of the augmentation with the help of LM-tests for autocorrelation (a more detailed description can be found in Hayo (1994)).

We commence our discussion with the core of the paper: the empirical analysis of the European demand for the EMU candidates. Drawing on the large theoretical and empirical literature on this issue (see Laidler (1993, 160f)), we estimate a demand function for real money. The deflator for money is the implicit price deflator derived from the construction of European nominal and real GDP.

[8] One may also think of using ‘fundamental equilibrium exchange rates’ for converting the values. But there still exist numerous difficulties connected with this approach, which are even admitted by some of its main proponents (see Williamson (1994)).

4. Cointegration Analysis and Long-run Money Demand

We start off our analysis by looking at the results of modelling the aggregate demand for money for the prospective member countries. In Table 1, the estimates for the cointegrating vector of the EMU11-variables are given. In addition to the variables named above, a constant, deterministic dummies and a trend term were added as unrestricted variables to the analysis.

Tab. 1: Estimating and testing the cointegration vectors for EMU11

	Narrow Money			Broad Money		
No. of lags	3			2		
H_0	Eigenvalue	LR(r,r+1)	LR(r,N)	Eigenvalue	LR(r,r+1)	LR(r,N)
r = 0	0.26	26.6*	41.9**	0.23	26.2*	43.9**
r ≤ 1	0.09	9.8	15.2	0.12	12.7	17.6
r ≤ 2	0.05	5.4	5.4	0.05	4.9	4.9
	LMEMU11	LGDPEMU11	INTEMU11	LMQEMU11	LGDPEMU11	INTEMU11
$\hat{\beta}'$	1	-1.55	0.21	1	-1.16	0.03
$\hat{\alpha}'$	-0.02	-0.01	-0.26	-0.15	-0.02	-1.02

Notes: LR(r,r+1) are the test statistics for the maximum eigenvalue test, and LR(r, N) for the trace test. The critical values are taken from Osterwald-Lenum (1992). $\hat{\beta}$ is the cointegrating vector and $\hat{\alpha}$ the corresponding adjustment vector. * (**) indicates significance at a 5% (1%) level.

In the first vertical part of the table, the outcomes for narrow money, and in the second part the ones for broad money, are displayed. The second row of the table indicates the remaining number of lags of the respective VAR. In the following section of the table, the tests on the cointegrating vectors are given. Two likelihood ratio tests are calculated, the maximum eigenvalue test (LR(r,r+1)) and the trace test (LR(r,N)) (see Johansen and Juselius (1990) for more details). Throughout this study, one (two) asterisk(s) indicates a rejection of the null hypothesis at a 5% (1%) level.

In the next row, the actual estimates of the significant cointegrating vector, named $\hat{\beta}$, are recorded. Finally, in the last part of the table, the estimates of the relevant adjustment vector for cointegrating vector $\hat{\beta}$, labelled $\hat{\alpha}$, are collected. The first element of $\hat{\alpha}$ gives the weight attached to the cointegration vector, $\hat{\beta}$, standardised with respect to money.

4.1 Narrow Money Cointegration Vector

Starting off with narrow money, we find that exactly one significant cointegrating vector can be extracted. The relevant adjustment coefficient (-0.02) is small in absolute terms and negative.

In another step we test restrictions on the cointegration and adjustment vectors by applying likelihood ratio tests involving the eigenvalues of the system - which are distributed as Chi^2 random variables - and setting the rank equal to one. The results are given in Table 2:

Tab. 2: Testing restrictions on cointegrating and adjustment vectors for narrow money

Restrictions on $\hat{\beta}'$	$\hat{\beta}'=(1,-1,0)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$
Restrictions on $\hat{\alpha}$	$\hat{\alpha}$ unrestricted	$\hat{\alpha}$ unrestricted	$\hat{\alpha}=(u,0,0)$	$\hat{\alpha}=(u,0,u)$	$\hat{\alpha}=(u,u,0)$
Test statistics	$Chi^2(2)=16.8$**	$Chi^2(1)=0.27$	$Chi^2(3)=8.6$*	$Chi^2(2)=7.1$*	$Chi^2(2)=3.3$

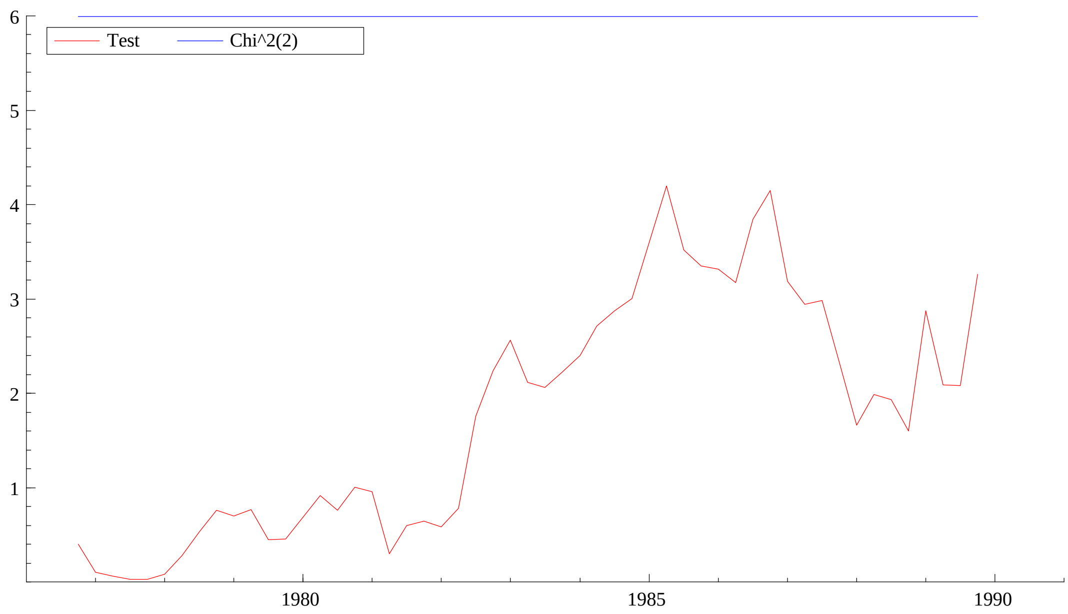
Note: 'u' indicates unrestricted estimation of the respective parameter. * (**) indicates significance at a 5% (1%) level.

In the second column of this table, restrictions reflecting the strong version of a classical money demand function are being tested, namely assuming a unit income elasticity of money demand and a zero interest rate semi-elasticity. The test statistic given in the last line of the table shows that the restrictions have to be rejected. But dropping the constraint on the interest rate - as shown in column three - leads to a restriction that cannot be rejected at a 5%-significance level. In the next step, restrictions on the adjustment vector are introduced. In column four the unit coefficient restriction on the cointegration vector is carried over, and it is jointly tested with the hypothesis that the income and interest variables are weakly exogenous with respect to the money demand equation. We reject this hypothesis, as well as the one where the zero constraint on the income variable has been dropped presented in column five. In column six, the joint hypothesis of an income elasticity of unity and money being weakly exogenous with respect to the interest rate variable cannot be rejected. The restricted cointegration vector based on the last column in Table 2 takes the following form:

$$ECLM_t = LM_t - LGDP_t + 0.10\ INT_t \qquad (2)$$

As can be seen when comparing this result with the unrestricted estimate given in Table 1, both income and interest rate semi-elasticity estimates are lower now. To see whether this restriction holds up over time, the LR-test of this restriction has been computed recursively and printed in Figure 1. As is apparent from the graph, the restriction does not even come close to a rejection at the 5%-level. Thus in the estimation of the dynamic model presented below, an error-correction term is used, the computation of which is based on Equation (2).

Fig. 1: Recursively computed test of cointegration restriction for narrow money



Moreover, the estimation will take place within the framework of a two-equation system, i.e. using equations for money and income.

4.2 Broad Money Cointegration Vector

Results for the cointegration analysis for broad money are shown in the right part of Table 1. Again we find one significant cointegrating vector. Proceeding as before for narrow money, we test a number of restrictions on the results of the cointegration analysis, the results of which are given in Table 3. Here only the zero restriction on the interest rate in the cointegrating vector is rejected. Hence both income and interest rate can be regarded as weakly exogenous with respect to the money demand equation.

Tab. 3: Testing restrictions on cointegrating and adjustment vectors for broad money

Restrictions on $\hat{\beta}'$	$\hat{\beta}'=(1,-1,0)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$	$\hat{\beta}'=(1,-1,u)$
Restrictions on $\hat{\alpha}$	$\hat{\alpha}$ unrestricted	$\hat{\alpha}$ unrestricted	$\hat{\alpha}=(u,0,0)$	$\hat{\alpha}=(u,0,u)$	$\hat{\alpha}=(u,u,0)$
Test statistics	$Chi^2(2)=13.1$**	$Chi^2(1)=1.21$	$Chi^2(3)=2.36$	$Chi^2(2)=2.03$	$Chi^2(2)=1.88$

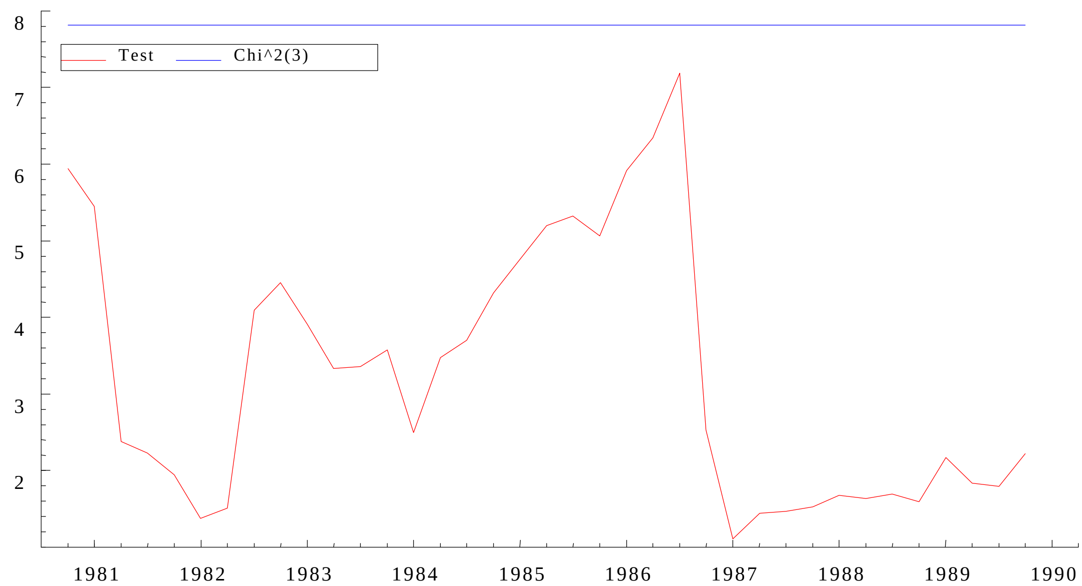
Note: 'u' indicates unrestricted estimation of the respective parameter. * (**) indicates significance at a 5% (1%) level.

The resulting error-correction term for the dynamic model of broad money is calculated as:

$$ECLMQ_t = LMQ_t - LGDP_t + 0.023\ INT_t \tag{3}$$

Again we test the restriction recursively and the result can be found in Figure 2.

Fig. 2: Recursively computed test of cointegration restriction for broad money



The restriction is valid over the estimated period at all data points, especially from 1987 onwards. Consequently, the relation given in Equation (3) is used as an error-correction term for broad money in the subsequent analysis.

5. Estimating Short-Run Money Demand Functions

In this section, short-run, dynamic money demand functions are estimated with the help of error-correction models. In addition to the variables presented in the preceding sections, the change in the inflation rate and some dummy variables were added to the models.

Starting with the latter, impulse dummies for the last quarter of 1986 and the first quarter of 1987 have been included. The reason for that is that there is a break in the money variables for France based on a change in the series as given in the IFS. In the case of broad money, another impulse dummy - for the last quarter of 1969 - was added, since the observation appeared to be an outlier, causing some problems with non-normality of the residuals.

More importantly, the change in the European inflation rate – defined as first differences of the change of the GDP deflator (ΔINF_t) – was also added as a regressor. In a world without any rigidities, the inflation rate should play no role in money demand estimates, since both money and income are measured in real terms. At least two arguments can be brought forward which rationalise the inclusion of the inflation rate. First, when investors hold real assets as a large proportion of their portfolios, and assuming that the inflation rate measures the yield of real assets, then changes in the inflation rate can have an effect on the demand for money. Second, it is possible that interest rate and inflation rate are not perfectly correlated (see Baba et al. (1992)) due to reasons such as distorted money and capital markets or administrative influences on the formation of interest rates.

But including the inflation rate - which was found to be I(1) - in the cointegration relationship destroys the theoretically consistent estimates obtained from the three variable vector. Therefore it was decided to include it in the short-run but not in the long-run part of the model. Moreover, the contribution to the modelling success by the inflation variable lies only in the reduction of the standard error of regression, while it does not improve the forecasting performance.

5.1 Modelling Narrow Money

Incorporating the considerations given in the previous paragraphs into the modelling process, we commence the discussion with the case of narrow money. A full error-correction system containing the variables in differences (Δ is the first-order differences operator) is estimated, including the first lag of the error-correction term computed in Equation (2) in levels. Then a general-to-specific reduction process based on F-tests at a 5%-significance level is used to eliminate the number of lagged variables. Finally, the parsimonious model presented later in Table 5 is estimated employing full maximum likelihood estimation techniques.

Before we come to the interpretation of the results, a number of diagnostic tests have been computed in Table 4 to evaluate the statistical properties of the model. None of the tests computed here indicates a violation of statistical assumptions.[9] The standard error is small for both money and income equations. A very positive impression is also conveyed by the forecasting statistics. The null of stable parameters of the model can neither be rejected in the Chi^2-form of the test, nor in its approximate F-test form.

Tab. 4: Diagnostics for dynamic model of narrow money demand

Vector-Residual-Tests:	Equation-Based Tests:	
	ΔLM	ΔLGDP
Vector AR Test:	AR Test:	AR Test:
$F(20,164) = 0.6$	$F(5,84) = 1.6$	$F(5,84) = 1.9$
Vector Normality Test:	Normality Test:	Normality Test:
$Chi^2(4) = 6.6$	$Chi^2(2) = 3.0$	$Chi^2(2) = 3.5$
Vector White-Test (A):	White-Test (A):	White-Test (A):
$F(45,223) = 1.2$	$F(15,73) = 1.4$	$F(12,80) = 1.1$
Vector White-Test (B):	White-Test (B):	White-Test (B):
$F(126,144) = 1.0$	$F(42,46) = 0.99$	$F(42,46) = 0.85$
	ARCH-Test:	ARCH-Test:
	$F(4,81) = 0.49$	$F(4,81) = 0.94$
Standard Errors:	0.011	0.009
Forecasting Tests:		
Standard Chow-type test: $Chi^2(40) = 50.9$, $F(40,93) = 1.27$		
Allowing for parameter uncertainty: $Chi^2(40) = 48.3$, $F(40,93)=1.21$		
LR-Test against the system: $Chi^2(7) = 8.5$		

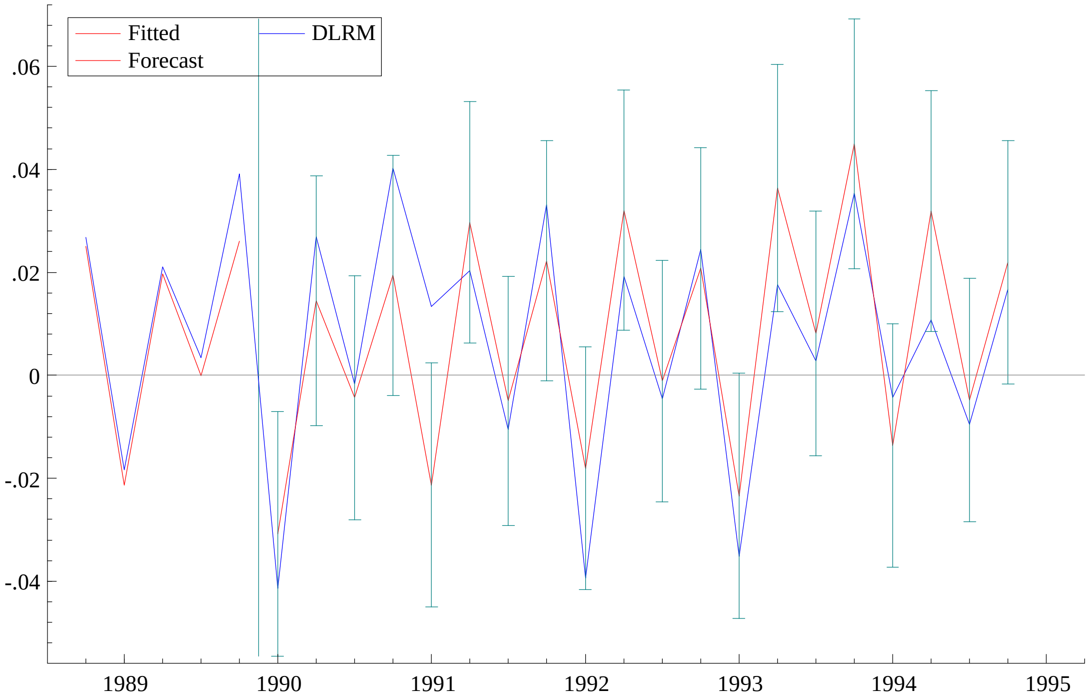
Note: White-Test (A) includes only squared regressors in the auxiliary regression, while White-Test (B) also includes cross-products of the regressors. The latter may also be interpreted as a test for functional form. * (**) indicates significance at a 5% (1%) level.

The predictive ability of the money demand equation is graphically demonstrated in Figure 3. In this graph, one-step ahead forecasts with their corresponding 95%-confidence intervals are printed (+/- two standard errors) along with the actual values for these data points. It can be seen that the actual values never fall outside the confidence intervals except in 1991:1. This failing is readily explainable, though: it is simply connected with the economic consequences of

[9] A detailed description of the tests can be found in Doornik and Hendry (1997).

German re-unification. Note how closely the forecasts track the actual values even at the end of the forecasting period.

Fig. 3: Out-of-sample forecasts of narrow money demand equation

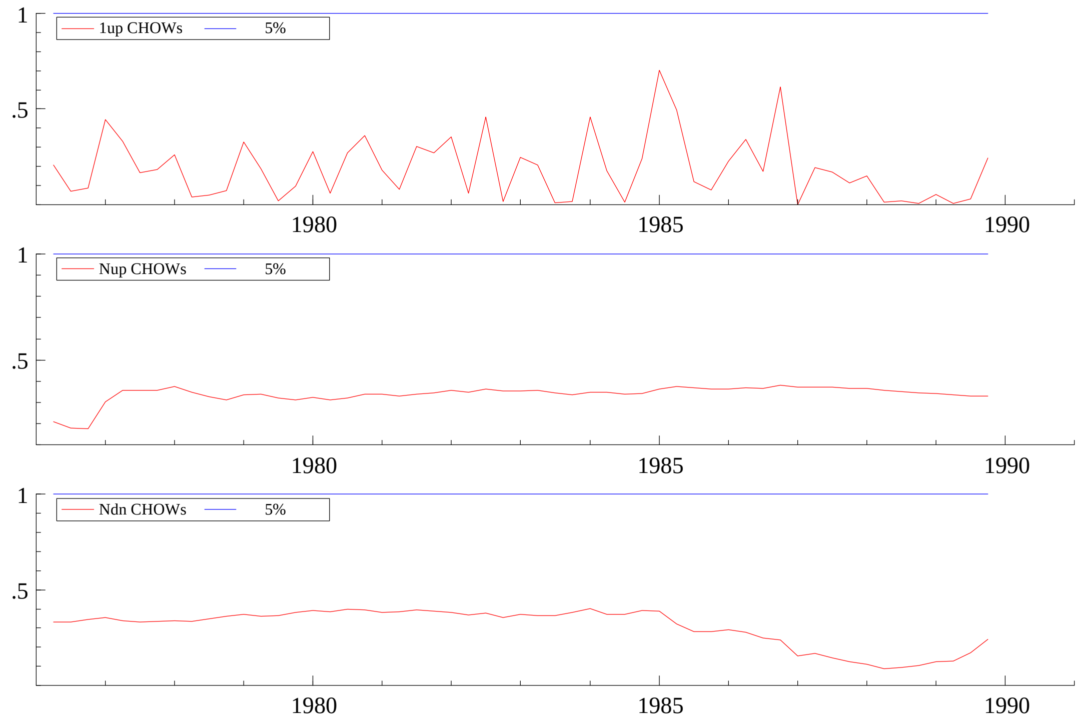


Connecting this finding with the literature on the effects of German monetary union mentioned above, we can support the view that this event only caused temporary instability, at least in the European aggregates.

Using recursive estimation, the stability characteristics can be further analysed. In Figure 4, the results of three variants of the Chow-test are plotted. In the first of the three graphs, the Chow-test is computed in a one-step progression from the start of the sample (1up). In the second graph, the test statistic is computed against the starting point of the sample while moving toward the end of the sample (Nup), and in the last graph the statistic is calculated against the sample endpoint while also steadily approaching this endpoint (Ndn). It is apparent that none of the tests comes even close to rejecting the null hypothesis of stable parameters at a 5% significance level.

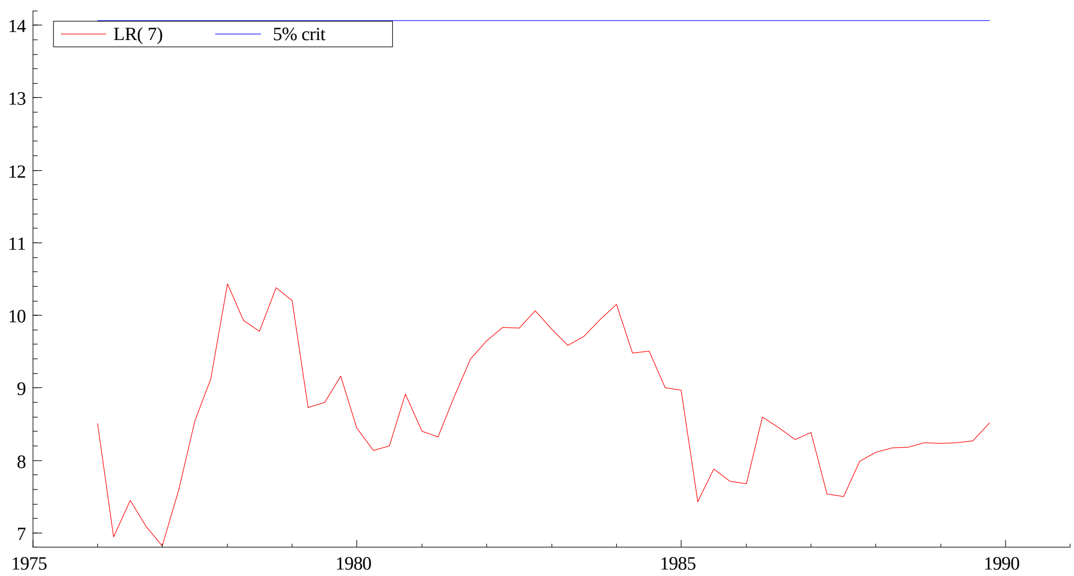
In the last row of Table 4, the encompassing test is presented, which does not reject. This means that the model can be seen as a valid reduction of the underlying unrestricted VAR.

Fig. 4: Recursive Chow-tests for narrow money model



To see whether the over-identifying restrictions hold up over time, the encompassing test is also calculated recursively and printed in Figure 5.

Fig. 5: Recursive encompassing test for narrow money



Again we can conclude that there is no rejection of the null hypothesis, the over-identifying restrictions would be valid over the whole sample period. In view of these excellent results, we can now look at the actual estimates given in Table 5.

Tab. 5: Estimating a dynamic model of narrow money

Variable	Coefficient	Std. Error	t-value	t-prob.	HCSE
		Equation for ΔLM			
ΔINT_{t-1}	-0.01	0.003	-3.55	0.0006	0.003
ΔINF_{t}	-1.03	0.278	-3.71	0.0004	0.262
ΔINF_{t-1}	-0.55	0.252	-2.17	0.0323	0.221
$ECMLM_{t-1}$	-0.02	0.006	-3.88	0.0002	0.005
DU87Q1	0.05	0.011	4.39	0.0000	0.003
Constant	-0.02	0.004	-4.29	0.0000	0.003
$Seasonal_{t}$	-0.05	0.003	-14.6	0.0000	0.004
$Seasonal_{t-2}$	-0.03	0.003	-9.70	0.0000	0.003
		Equation for $\Delta LGDP$			
ΔLM_{t-1}	0.21	0.044	4.76	0.0000	0.052
$\Delta LGDP_{t-3}$	0.18	0.079	2.32	0.0225	0.092
$ECMLM_{t-1}$	-0.02	0.002	-8.03	0.0000	0.002
DU87Q1	-0.01	0.009	-1.52	0.1325	0.002
$Seasonal_{t}$	-0.02	0.002	-8.15	0.0000	0.003

In the money demand equation, only three dynamic variables are left. First we find an interest rate variable lagged by one period with a negative coefficient. This means that additionally to the negative impact of the interest rate as captured within the long-run equilibrium, there is a negative short-run influence, strengthening the adjustment of money demand to interest rate changes. This is similarly true of a change in the inflation rate, since both the current and a lagged value are negative and significantly different from zero. Thus although the inflation rate does not appear to be important for the long-run equilibrium of money demand, it has an effect in the short-run. The opposite seems to be the case for the income variable.

The error-correction term is highly significant and it shows the theory-consistent negative sign. However, the absolute influence of deviations from the long-run equilibrium is relatively small. Consequently, when money demand is pushed out of equilibrium by exogenous shocks, the forces pulling it back are comparatively small. Finally, the dummy capturing the break in the statistical definition, a constant and some seasonal dummies are of importance too.

Income growth is characterised by being positively influenced through one-period lagged money growth. This finding can be regarded as evidence of Granger-causality going from money to output. Another determinant is the value of GDP growth lagged three periods. As the sign is also positive, there are persistency effects in growth rates present, even though the variables are stationary and the model allows for interdependencies with other factors.

The parameter of the error-correction term is also significantly negative and as small as the one present in the money equation. The dummy for the first quarter of 1987 is not significant employing normal standard errors. Even though the diagnostic tests do not indicate deviations from homoscedasticity, the value of the heteroscedasticity consistent standard error is much lower. In view of that, the variable has been left in the equation.

5.2 Modelling Broad Money

Based on the results of the cointegration tests, we can specify the money demand function as a single equation.

Tab. 6: Diagnostics for dynamic model of broad money demand

	Equation-Based Tests:
	ΔLM
	AR Test:
	$F(5,82) = 0.66$
	Normality Test:
	$Chi^2(2) = 1.04$
	White-Test (A):
	$F(16,70) = 0.76$
	White-Test (B):
	$F(41,45) = 0.65$
	ARCH-Test:
	$F(4,79) = 1.17$
Standard Errors:	0.0065
Forecasting Tests:	
Standard Chow-type test: $Chi^2(20) = 22.3$, $F(20,87) = 1.11$	
Allowing for parameter uncertainty: $Chi^2(20) = 20.1$, $F(20,87)=1.01$	
LR-Test against the system: $Chi^2(10) = 9.5$	

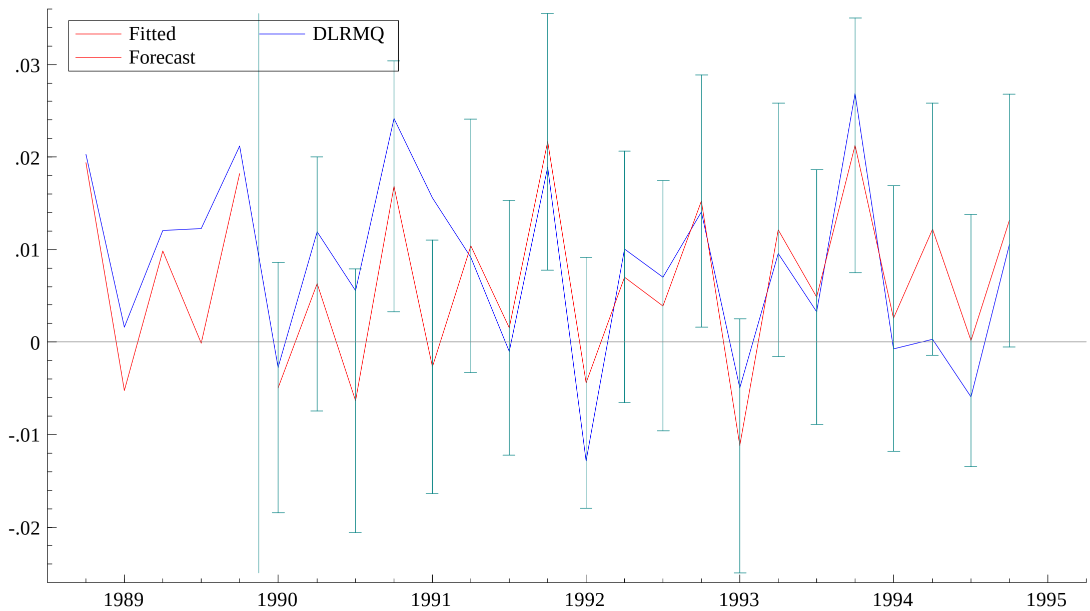
Note: White-Test (A) includes only squared regressors in the auxiliary regression, while White-Test (B) also includes cross-products of the regressors. The latter may also be interpreted as a test for functional form. * (**) indicates significance at a 5% (1%) level.

As indicated above, an additional dummy variable is used for the last quarter of 1969. The choice of this variable is not theory driven, and one needs to be careful not to introduce too many sample specific variables into the model. The resulting gain in fit will then often be lost in terms of forecasting performance.

The model estimates are presented in Table 7, but before looking at them we have to analyse the statistical adequacy of the equation. Diagnostic test results are displayed in Table 6. As before, none of the test statistics indicate a violation of the null hypotheses. The standard error of the regression is very small.

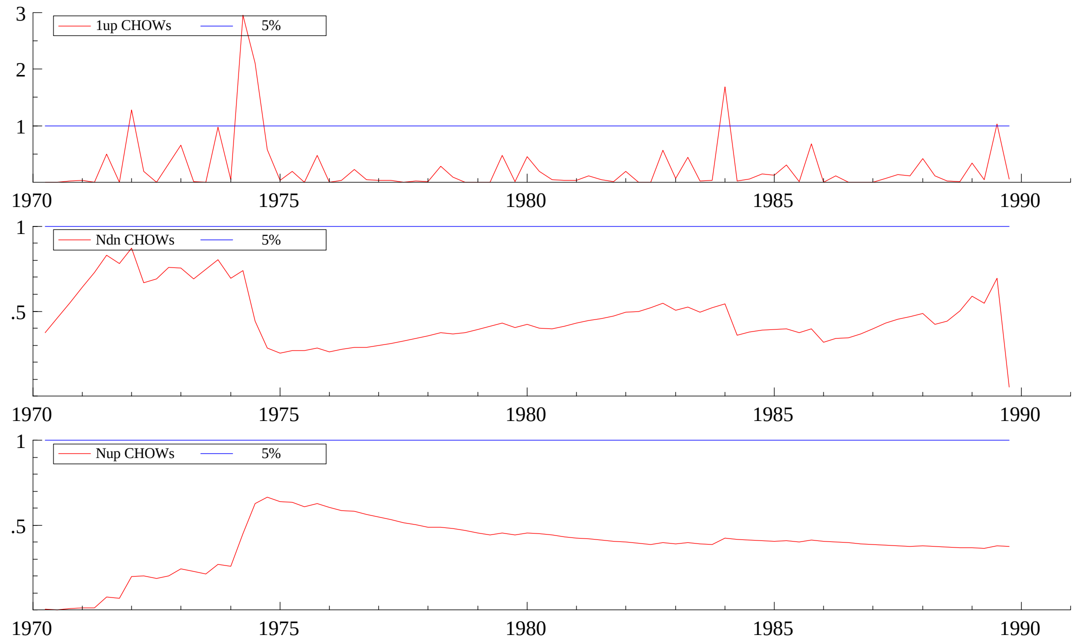
The forecasting properties are good, as can be seen from Figure 6. We find the temporary break in the beginning of 1991 again, which is connected with the turbulence of German money after reunification. If the model was extended to estimate the money demand function including the observations from the 1990s, a dummy variable was sufficient to take account of this outlier. Apart from that, all observations stay within their respective confidence intervals. It is reassuring to see that the inclusion of an additional impulse dummy has not improved the fit of the model at the expense of its out-of-sample stability.

Fig. 6: Out-of-sample forecasts of broad money demand equation



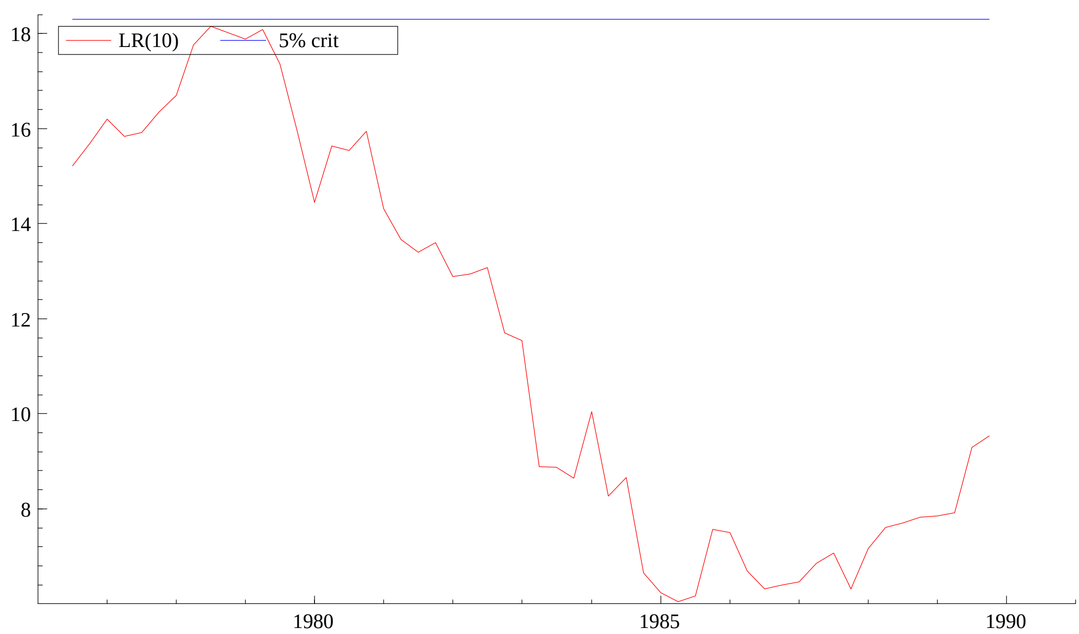
Computing recursive Chow-tests to further explore the stability properties reveals the following picture (see Figure 7). Here we observe some violation of the one-step stability tests. It can be argued, though, that most of these are simply outliers, especially the ones connected with the oil crisis in 1973. This conclusion is strengthened by the finding that none of the other two tests – decreasing and increasing test period – show any violations.

Fig. 7: Recursive Chow-tests for narrow money model



Finally, we look at the test of overidentifying restrictions computed recursively in Figure 8.

Fig. 8: Recursive encompassing test for broad money



It is apparent that the test never rejects even though it gets close to being significant at the end of the 1970s. Thus the restriction on the VAR appears to be valid over the sample period.

Next we come to the actual estimates of broad money demand in the short-run (see Table 7).

Tab. 7: Estimating a dynamic model of broad money

Variable	Coefficient	Std. Error	t-value	t-prob.	HCSE
		Equation for ΔLMQ			
ΔLMQ_{t-1}	0.18	0.066	2.78	0.0066	0.058
ΔLMQ_{t-3}	0.13	0.055	2.36	0.0205	0.048
ΔINT_{t-2}	-0.01	0.002	-3.24	0.0017	0.002
ΔINF_{t}	-0.43	0.145	-2.95	0.0040	0.148
$ECMLMQ_{t-1}$	-0.02	0.004	-5.79	0.0000	0.004
DU69Q4	-0.03	0.007	-4.55	0.0000	0.002
DU86Q4	0.05	0.007	7.71	0.0000	0.003
DU87Q1	0.06	0.008	6.97	0.0000	0.004
Constant	0.01	0.003	3.91	0.0002	0.002
$Seasonal_{t}$	-0.03	0.002	-11.9	0.0000	0.002
$Seasonal_{t-1}$	-0.01	0.002	-5.01	0.0000	0.002
$Seasonal_{t-2}$	-0.02	0.003	-8.50	0.0000	0.003

The first regressors explaining short-run money demand are money lagged one and three periods. Hence inertia appears to be important in explaining the actual value of money growth. Both parameters are positive indicating that higher money growth in one period has a positive influence on money growth in the future.

The second influence is the change in the interest rate. Economic agents react to changes in opportunity cost with a lag of two quarters. But then money holdings will be reduced. Thus in addition to the importance of the interest rate for the long-run equilibrium, we also observe a negative short-run effect. Again we find that current inflation plays a role and - as in the case of narrow money - it has a restraining effect on money demand. The error-correction term shows a negative coefficient and is significantly different from zero, while its absolute value is small. Consequently, deviations from the long-run equilibrium do not exert a strong influence on actual money growth. Finally we have the dummy variables capturing breaks, outliers and seasonal effects.

It is interesting to note that in the short-run GDP growth does not appear to play a role in this system apart from its influence via the error-correction term. This might be due to the fact that its influence through the long-run equilibrium is relatively stronger compared to the case of narrow money resulting from the much lower weight of the interest rate in the cointegrating relation. Moreover, the decision to hold broad money is less dependent on transaction purposes.

6. Conclusion

To summarise the results of this paper, we should note the following: The estimated money demand functions for prospective EMU member countries appear to be stable over time. For both narrow and broad money aggregates do we find an income elasticity of money demand of unity. With respect to interest rate (semi-)elasticities, a value of 0.10 was estimated for narrow and 0.023 for broad money. The higher sensitivity of narrow money aggregate to changes in the interest rate could reflect the fact that it contains less interest bearing components and thus people suffer relatively higher opportunity costs after a rise in interest rates than by holding broad money.

Coming back to some of the points raised in the introduction or discussed in section 2, the following, more or less tentative, additional conclusions can be drawn from this study:

First, can we say something more about the aggregate series we have been working with, are they making any economic sense? Looking at the results, the answer is a clear yes. They are consistent with the other estimates presented in the literature, even though this does not say much about the general admissibility of modelling European aggregate demand functions. But the estimated long-run parameters are very reasonable from a theoretical point of view too, they are robust with respect to the size of country group, and they fall within the interval spanned by estimating the long-run component of national money demand functions as well (see Hayo (1998)). If one believes in the fruitfulness of estimating money demand functions in this way (see Hoffman and Rasche (1996) for some forceful arguments), the backward induction from the reasonableness of the results to the validity of the employed series suggests taking the analysis seriously. It should be clear, though, that the methodological basis of backward justification is rather questionable, especially if one does not adhere to a strictly instrumentalist view of science.

Unsurprisingly, the aggregate series are much smoother than the underlying national ones. While the number of lags needed to remove any autocorrelation from the residuals can be quite large for some countries, this is no problem at all for the aggregate series. The VAR can be modelled with only few lags and, correspondingly, the short-run dynamics of the aggregate series are somewhat underdeveloped. This is a discovery also reported by almost all European money demand studies. Using a slightly different econometric approach, Clausen (forthcoming) systematically compares the estimated adjustment lags of national versus European money demand functions for the actual EMU founding members. Based on the result of shorter adjustment lags for the European money demand equation, he goes on to argue that the ECB will find it easier to pursue monetary policy than the national central banks.

The finding of relatively short adjustment lags may not be a problem in principle, but it leaves unanswered the uncomfortable question: why is it the case that adjustment is, generally speaking, complicated and long at the national level and simple and swift at the aggregate level? One possible answer to this is to argue that shocks to money demand functions are asymmetric across countries and by aggregating the series these shocks cancel each other out, leading to a smoother overall appearance. If, after entering EMU, there is only the Euro left, we cannot be sure that this smoothing effect will prevail.

A similar point can be raised regarding the finding of cointegrating vectors. At a national level it can be quite difficult to obtain theoretically consistent and significant cointegrating vectors for some countries, while this is not a problem at all for the European series. For example, the sensitivity of estimated aggregate cointegrating vectors with respect to the chosen lag length is low. Beside the asymmetric shock smoothing argument, we could bring in the points related to money market integration, especially involving currency substitution. But it is unclear how much weight this argument can bear. We have used data ranging back to the sixties, and therefore the parameter estimates are very much influenced by an era when currency substitution definitely did not play a decisive role.

As indicated above, seen from the standpoint of a policy maker, the results of this study are quite encouraging. The finding that a stable aggregate money demand appears to exist would make a successful operation of money targeting at a European level possible. Moreover, the short-run adjustment periods are extremely low, thus also helping to foster the execution of monetary policies. After accounting for the likely occurrence of temporary and short-term post-unification noise in the data, the ECB should be able to rely on past data to estimate a European money demand and maybe other characteristics of the aggregate money market. However, we can also expect an adjustment of economic agents to this new situation, which may invalidate the information drawn from past observations in the longer term.

Finally, at least with respect to the stability of the money demand function, the actual decision by the European Council on EMU membership can be seen as relatively uncontroversial. The characteristics of aggregate European money demand functions are very similar over different country groupings (see Hayo (1998, p. 172ff)). This would make it unlikely that European money demand would be significantly negatively affected if countries with a relatively less stable national money demand, like Sweden or the UK, entered EMU at a later stage.

Appendix

Tab. A1: Variables and Unit-Root Tests

Variable	Description	ADF-Value	Variable	ADF-Value
LM	log of real narrow money	-0.06 [C,S,T,4]	ΔLM	-0.88** [C,S]
LMQ	log of real broad money	-0.007 [C,S,1]	ΔLMQ	-0.64** [C,S,T]
LGDP	log of real GDP	-0.009 [C,S,1,3,6]	ΔLGDP	-0.83** [C,S,T,3,4,5]
INT	Aggregate interest rate	-0.02 [S,1]	ΔINT	-0.53** [1]
INF	Inflation rate based on aggregate GDP deflator	-0.07 [S,1,2]	ΔINF	-1.8** [1]

Notes: Δ is the first difference operator. One (two) asterisk(s) indicates a rejection of the Null at the 5% (1%) significance level. The critical values are taken from MacKinnon (1991). The lags and deterministic variables (constant, seasonals, trend) used in the final specification of the ADF-test are given in square brackets.

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